Chapter 3
Strategically Flexible Production: The Multi-focused Manufacturing Paradigm. A Review and Outlook

Chris A. Voss

Abstract In the Nineties companies were experiencing a number of different strategic and organizational models in running their manufacturing activities to overcome the limitations of the Fordist paradigm in the face of growing complexity and turbulence of the environment. Despite the differences, it was possible at that time to recognize few guiding principles that were common to the most advanced and effective models. In particular, the original paper summarized these principles in three: i) Multi-focusedness and strategic flexibility; ii) Process Integration; and iii) Process Ownership. This approach was called the Strategically Flexible Production. Using data from the International Manufacturing Strategy Survey, the authors were able to show the wide adoption of the paradigm across the sample and across all regions. It also tested the impact of the new paradigm on operational performance, showing better results obtained by those companies that fully adopted the paradigm compared to partial or non-adopters. The commentary underlines that after twenty years the value of this paper resides first of all in having challenged the established paradigms of manufacturing strategy at that time. Also, the paper was among the first ones to underline the value and importance of strategic flexibility and multi-focusedness for manufacturing companies. On both these aspects the paper has been an important platform for future work and for the evolution of the field.

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3.1 Original Paper[1]

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Research background: beyond Fordism

Over the past 20 years manufacturing and assembly activities have experienced many changes, not only technological but also organizational and managerial.

A wide range of innovations have been implemented across countries and industries, such as just-in-time, total quality management, concurrent engineering and others. As a result, both the internal organization of the factories and the external environment – including market demand, technology development, workforce

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education and expectations, labour and capital market– appear to be very different today from the general features that dominated the industrial development in the past, which is generally referred to as the Fordist paradigm. This paradigm shift has been described from both a macro and institutional perspective; see the comprehensive reviews by Roobeek[1] and Kenney and Florida[2]. Also, from a managerial point of view, clear-cut breaks with the consolidated Fordist practices have been highlighted. For example, Jaikumar[3] proposed new mission statements about the management of new technologies, Drucker[4] and Hayes et al.[5] put forward new principles to organize and manage manufacturing systems, others pointed out new performance requirements; e.g., Slack[6] on the flexibility and Stalk and Hout[7] on time-based performances. However, with all the literature on paradigm shifts in manufacturing, some valid questions are still open:

- Can a new manufacturing paradigm be identified, despite the different strategic choices that industrial companies make and the different internal and external conditions they have to meet?
- Is this paradigm a definite breakthrough with Fordism? Is it possible to find out a limited set of shared principles to design and manage the production systems, that pools different models and paths of innovations?
- If the paradigm exists, how can it be defined and operationalized to support empirical investigation?
- How is the emerging paradigm adopted across countries and industries?
- What is the performance improvement along specific measures that comes from the orientation to the paradigm?
- Are there different paths to achieve the full orientation to the paradigm?

This article explores the answers to some of these questions. Assuming that a new paradigm is actually emerging, we define and operationalize it precisely, and investigate its adoption, performance improvements and innovation tracks, by using data from the International Manufacturing Strategy Survey (IMSS), a worldwide research project involving 600 companies from 20 countries, within the assembly industry.

The basic assumption about the emergence of a new paradigm entails that the different post-Fordist experiences are drawing together; also, despite the variety of strategies and innovations implemented, both organizational and technological. Indeed, the shift away from mass production to a new industrial organization has followed different paths, some of which drew enthusiastic attention but were abandoned or reshaped later on – e.g. the experiences of Volvo in Kalmar and Uddevalla and the so-called "neo-craftsmen" models. Other examples (see also [2] for a review) include the model of "flexible specialization"[8]. Cases in point are the textile district in Northern Italy and the textile machinery district of Baden-Würtemberg. Though fascinating, "flexible specialization" appeared to be inapplicable to the most important capital intensive sectors. Also, the Japanese way has been regarded as a replacement for the Fordist paradigm. The development of the just-in-time concept at Toyota since the 1950s and further refinements seem to discard the basic principles of Fordism (see, for example [9]). However this view has been questioned [10] and the Toyotism with its superexploitation of workers'

capabilities has been depicted also as "hyper-Fordism". Indeed, western manufacturers have experienced many difficulties in adopting or adapting the Japanese style of management and way of organizing the production systems.

Ever more companies are drifting away from Fordism, and it seems that a new paradigm is emerging, which embodies some features of the previous post- Fordist experiences, but also introduces radically new aspects. Based on a limited set of shared principles to design and manage production systems, the paradigm pools different models that companies implement to cope with the competition in their marketplaces and to exploit their capabilities. These principles appear to discard the traditional Fordist assumptions about strong labour specialization, heavy control hierarchies, functional organization, tradeoff management, co-ordinating mechanisms based on formal procedures and so on. Indeed, the whole research project on what we call the multi-focused manufacturing paradigm, moves from the idea that a clear distinction is needed between three levels:

(1) The *techniques* to innovate the production systems, that is, the technological, managerial and organizational innovations.
(2) *Manufacturing models,* i.e. the systemic implementations of combinations of techniques that companies select and customize, according to their internal and external environment; the implementation results in specific practices that suit the company's situation best.
(3) The emerging *multi-focused manufacturing paradigm,* that is a limited set of new principles that underpins the innovation techniques and pools the manufacturing models. This new paradigm is supposed to replace the prevailing *modus operandi* within different countries and assembly industries, which is generally referred to as the Fordist paradigm.

A vast body of literature has already investigated the adoption and diffusion of the single techniques. In addition the transferability of some successful models has been studied, e.g. the "Toyota model" – just to discover that they can hardly be imitated, due to a number of country-specific factors. The basic assumption of the present research is that the single innovative techniques are actually universal and thus relatively easy to imitate. Consistent and, hence, effective combinations of these techniques are much more difficult to achieve. Exactly which combination is the most suitable for a company depends on: contextual factors – for example relating to country; industry and company size – technology; strategy and goals.

The consistency of a manufacturing paradigm

The rising of the multi-focused manufacturing paradigm comes from the environmental changes that have taken, and are still taking, place. These require companies and their production systems to adapt in order to remain effective. Many authors indicate how manufacturing should be organized in order to meet present market needs, resource availability, workforce expectations and so on (e.g. [11-13]). In addition, the effectiveness of manufacturing systems has been linked theoretically to their consistency, i.e. the fit between the component elements of the organization

and its environment (e.g. [14]). Hayes and Wheelwright[13] distinguish external and internal consistency. External consistency refers to the match between the manufacturing strategy and the business environment of the company. Internal consistency refers to the match within the manufacturing function and across functions within the business unit. So, environmental changes call for new internal and external consistency. If the environmental changes are big enough they may not only require changes on technique level or model level but even on paradigm level.

As effectiveness is a relative dimension, to assess the current and future strengths of the adopters of a new paradigm, internally and externally consistent, it is advisable to describe their position relative to rivals. This is in line with Pfeffer[15], who maintains that effectiveness can only be assessed comparatively. We can measure the position of a company relative to a competitor via two dimensions:

(1) its relative position regarding performance in the marketplace;
(2) the relative speed of organizational change aimed at improving performance[14].

Here we follow the second alternative, by addressing the question as to whether the multi-focused manufacturing paradigm enables a better degree of performance improvement than companies that have a lower degree of adoption of the paradigm. We expect cumulative effects on performance improvements depending on different degrees of adoption of the paradigm.

Several studies prove the effectiveness of manufacturing improvement programmes. Individual programmes proved to be associated with individual, related performance improvements, but success in manufacturing seems to require synergistic investments in a wide portfolio of programmes[16]; world-class companies, adopting a wide range of best practices, perform well on a wide range of measures[17-18]. In addition, cumulative effects on different performances have been highlighted – see the "sandcone model"[19] – and some techniques or approaches demonstrated to improve simultaneously different performances regarded as antithetical[20], thus shifting traditional trade-offs. This kind of literature explores the practice-performance link, either individually or synergistically. In this contribution we move to the paradigm-performance link. In fact, the actual possibility to improve manufacturing performances through innovative activities depends on their proper implementation[21]. In our view, the orientation to the multi-focused manufacturing paradigm, whatever the programmes or the practices implemented, can measure the success of the implementation.

The multi-focused manufacturing paradigm

The basic principles

Recently, much has been written on the general changes that occur in the manufacturing systems. For example, [4,5] and [22] have proposed conceptual frameworks that identify a limited number of basic criteria. All these contributions suggest a

number of principles underpinning different manufacturing models. Though there are different emphases in those proposals, they can be regarded as coherent identifications of a unique paradigm, based on the external and internal consistency. Actually, today's external consistency seems to require:

- multiple performances required simultaneously;
- rapid priority changes;
- time effectiveness and quick response;
- increased quality of working life; and, in general,
- more involving and motivating tasks for an increasingly educated workforce.

To match these requirements, internal consistency is needed:

- global optimization;
- process focus in the organizational design just to keep quality and time fit with customer needs;
- development of internal capabilities and local problem solving;
- alignment of the manufacturing and the new product development processes.

According to [22], and integrating that framework in the light of other contributions, the multi-focused manufacturing paradigm can be articulated in three basic principles:

(1) *Multi-focusedness and strategic flexibility*. This first element relates to the manufacturing strategy. The multi-focused manufacturing paradigm drives companies to pursue a number of different objectives, traditionally regarded as antithetical, simultaneously, rather than focusing on specific objectives considered mutually exclusive. In addition, the paradigm implies a strategic flexibility, that is the ability to rapidly shift competitive and manufacturing priorities from one set of goals to another, within the same manufacturing system. This principle challenges the traditional assumption about rigid trade-offs involving manufacturing performances.
(2) *Integration.* This second element relates to production organization from a macro-structural perspective. It entails a resolute process focus, concerning especially those processes directly involved in the value-adding chain. Process integration is pursued across the internal functions and with both customers and suppliers. The previous emphasis on functional optimization should be abandoned in favour of a redesign of the company pivoted by the concepts of operating continuity, and process integrity, across the functional barriers.
(3) *Process ownership[23].* This third element also relates to production organization, from a micro-structural perspective. It aims at involving all employees at any hierarchical level, in decision making and problem solving. Delegation, involvement and knowledge of the process are embodied in this principle. The ultimate purpose is to develop at least some degree of local problem-solving capabilities, in order to detect and resolve process anomalies as soon as possible, and to avoid time consuming hierarchical referrals.

Both integration and process ownership are strictly related to multi-focusedness. In fact, integration fosters the globalization of the goals and the strategic

flexibility, making the organization more capable to follow market turbulence rapidly and to seize volatile opportunities. Process ownership is a basic contribution to enhance the quality of the outputs and to reduce the leadtime of the business processes, which in turn is the primary mechanism to reduce or, even better, avoid the trade-offs between performances traditionally regarded as antithetical. Thus the implementation of the three principles should be approached as an integrated problem, in order to achieve the required external and internal consistency.

The operationalization

The operationalization needed to investigate the adoption and the performances of the multi-focused manufacturing paradigm is based on a set of state variables that show, at a given time, to what extent a manufacturing unit is simultaneously oriented to multi-focusedness, integration and process ownership. The multi-focused manufacturing paradigm is a complex and multidimensional concept and relates to a complex system – i.e. the whole of the operations. It is difficult to describe a complex concept, using precise statements and numeric variables. Thus, the operationalization of the paradigm is necessarily based on a wide set of attributes, including also many, "linguistic variables, that is variables that are not numbers but words or sentences in a natural language"[24]. This set provides the basis to evaluate the degree of belonging of a unit to the paradigm, at a given time. In fact, the paradigm is not a "yes or no matter". The process of adoption is supposed to be progressive over time, so that at a certain point in time, a company may show a degree of belonging to the paradigm, maybe weak, strong, or all the gradations between the two extremes. For all the above reasons we use a fuzzy-logic approach (see for instance [24]). First, the set of state variables connected to the paradigm has been identified (see the items on the right-hand side of Figure 1).

Then, membership functions were built up to relate the single state variable to the degree of belonging, ranging from 0 (non-belonging) to 1 (complete belonging). The tuning of the membership functions is based mostly upon the literature on current best practices all over the world within the assembly industry (see Appendix 1 for some examples and [25] for a complete description). Starting from the basic set of variables, a hierarchical methodology was assessed that aggregates the leaves into the intermediate concepts, up to the three basic principles and to the paradigm as a whole.

Figure 1 shows the whole filter and in particular the operators we used for the aggregation of the leaves to the final degree of belonging to the paradigm (see also Appendix 2). These are mainly FUZZY-AND and AND operators, given the necessity of the presence at the same time of the three principles and their sub-principles. OR and FUZZY-OR operators were used when single items can be regarded as alternative with respect to the paradigm adoption. Of course, the so-computed degree of belonging to the paradigm embodies a certain degree of subjectivity, relating to the selection of the state variables, the definition of the

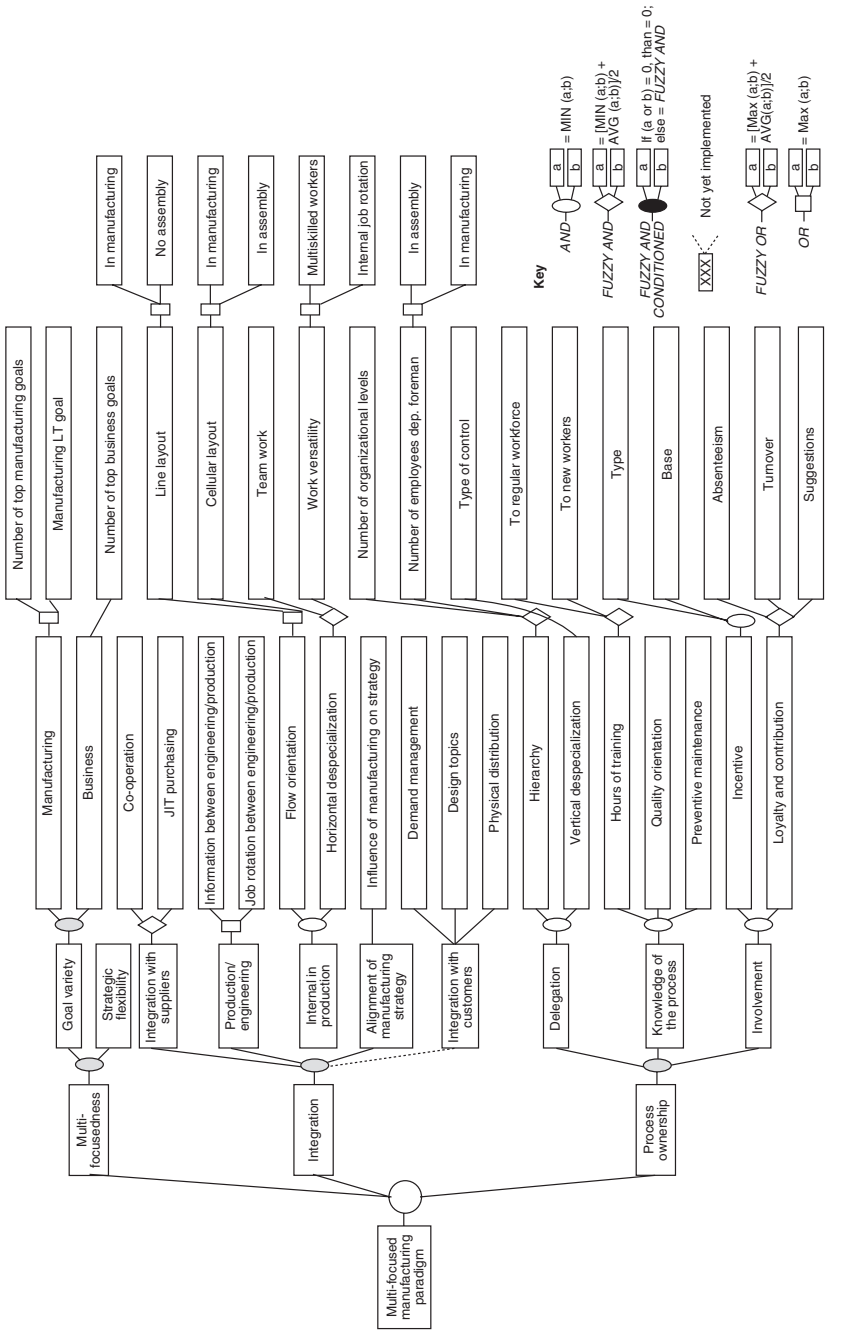

Figure 1. The operationalization of the multi-focused manufacturing paradigm

membership functions and the logic of the aggregation. The belonging to the multi-focused manufacturing paradigm is an absolute figure, but the degree of belonging to it can be regarded as a relative concept, useful to benchmark manufacturers from different countries and industries. In addition, the tuning of both the membership functions and the parameters of the fuzzy operators influences the absolute figure of the degree of belonging, but not the rank of the units within the sample, just saving the opportunity for cross-sectional comparisons.What is important to get a reliable rank is to select properly the OR/FUZZY-OR and the AND/*FUZZY-AND* operators, and the shape of the membership functions (increasing, decreasing, S-curve, step function, etc.).

Research hypotheses and methodology

The operationalization of the paradigm allows us to investigate two basic issues about the multi-focused manufacturing paradigm, respectively concerning:

(1) the adoption of the multi-focused manufacturing paradigm across industries and countries;
(2) the effectiveness of the multi-focused manufacturing paradigm, i.e. its ability to provide the adopters with superior improvement capabilities.

Two sets of specific hypotheses have been formulated for the two issues, respectively.

The adoption of the multi-focused manufacturing paradigm. We expected that some context factors may influence the adoption of the multi-focused manufacturing paradigm across industries and countries. We expect that the paradigm is adopted:

(1) Widely across countries but basically in the industrialized countries (Japan, North America and the most advanced European countries); the NICs and the less developed European countries will be less oriented to the multi-focused manufacturing. In fact, some unfavourable conditions are expected to hamper the paradigm adoption, such as the poverty of the public infrastructures, the shortage of a well-educated workforce, and low labour cost that is expected to attract mass production rather than innovation.
(2) Widely within the assembly industry and not only in the automotive industry, which attracted much of the attention since it was the cradle of both Fordism and post-Fordist experiences; we expect that the paradigm thrives also within other assembly sectors and mainly the electronic and electro-mechanical industries.
(3) By large and medium-sized companies, since they are expected to have a more robust managerial culture and to be more sensitive to managerial and organizational innovations.

The effectiveness of the multi-focused manufacturing paradigm. As far as effectiveness is concerned, we investigated if full adoption of the paradigm results

in a better performance improvement compared with companies which did not, or only partially adopted the paradigm. To address this issue we had to test:

- if companies that have adopted the principles of the paradigm are better capable of improving their performance compared to non-adopters;
- if partial adoption of the paradigm also qualifies for a better performance improvement;
- if the three principles of the paradigm reinforce each other.

A specific methodology has been built up to explore different degrees of adoption of the paradigm and the related performance improvements.

The "starmodel" in Figure 2 distinguishes companies with several degrees of belonging to the paradigm. This is also useful to study all kinds of innovation tracks which have to do with pursuing a full adoption of the paradigm. Three classes of belonging to the paradigm can be defined (see Figure 2):

(1) complete adoption, referring to the companies which have adopted all three principles (core adopters);
(2) partial adoption, i.e. companies that adopted two out of the three basic principles (star adopters);
(3) non-adoption, referring to companies that have only one principle out of three adopted or show no adoption at all (non-adopters).

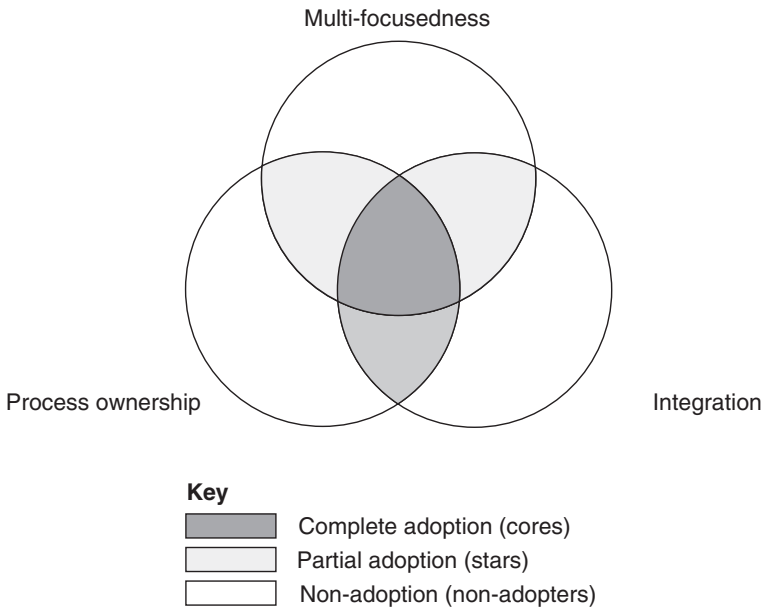

Figure 2. The starmodel: intersection of principles

We consider a principle to be adopted if the company has a score higher – for the single principle at hand – than the mean within the sample. In order to be a core adopter a company must have a score higher than the mean within the sample for all three principles.

In summary, our major line of argument is that:

- a new manufacturing paradigm is emerging and gradually replacing Fordism;
- it involves strategic multi-focusedness, integration of business processes across functions and process ownership;
- it can be operationalized using a fuzzy-logic approach;
- it is widely adopted across countries and industries, but there are some factors that influence its adoption;
- it results in a higher improvement capability compared to non-adopters; and
- different paths of innovation are feasible, since companies can implement the three principles according to different sequences.

The research sample

In order to explore the emerging paradigm on a global basis, we analysed the IMSS database but had to restrict ourselves to 443 companies. In fact, due to missing answers, it was not possible to evaluate properly 157 units out of 600, using the filter presented in Figure 1. Appendix 3 describes the procedure used to select processable respondents. The dropping of non-processable cases has not modified significantly the distribution of the original sample of the IMSS database (600 companies). Tables I and II show the distribution of the sample by industry and country.

The adoption of the multi-focused manufacturing paradigm within the assembly industry

The multi-focused manufacturing paradigm seems to emerge on a global basis. Looking at the global sample in Table III, it appears that strategic multi-focusedness is on hand for most of the companies, while process ownership seems to be the least adopted. Process integration lies in between. How can we explain the widespread poor orientation to process ownership?

Our primary concern was to verify the appropriateness of the membership functions we used to score the companies. All of them appeared to be realistic, since we could find companies in the sample that reached the complete belonging to the paradigm, for each item in the filter; also for those related to process ownership. However, while a number of companies can achieve the complete orientation to the three sub-principles of process ownership –delegation; knowledge of the process and involvement – separately, the sample does not comprise any company that has achieved them jointly. Indeed, many companies declare to implement

Table I. Distribution of the 443 processable companies by industry (number and percentage on total sample)

ISIC	Description	Respondents
381	Metal products (except machinery)	142 (32.1)
382	Machinery (except electrical)	66 (14.9)
383	Electrical machinery apparatus, appliances and supplies	92 (20.8)
384	Transport equipment	55 (12.4)
385	Measuring and controlling equipment, optical goods	40 (9)
–	Not specified or other	48 (10.8)

Note: Percentage in parentheses

Table II. Geographical distribution of the 443 processable companies

Country	Number
Sweden	42
Norway	11
Finland	16
Denmark	13
Great Britain	27
Germany	18
Austria	21
The Netherlands	20
Belgium	2
Italy	34
Portugal	24
Spain	24
USA	33
Canada	14
Mexico	51
Argentina	28
Brazil	21
Chile	4
Japan	16
Australia	24

multi-focusedness at the business and manufacturing level and integrate different business processes at the same time, while delegation, knowledge of the process and involvement appear, to some extent, to be mutually exclusive. This is hardly justifiable from a theoretical perspective, since the three sub-principles should reinforce one another, and no definite process ownership should be possible without the concurrency of the three sub-principles.

The possible explanation is that the adoption of the multi-focused manufacturing paradigm is a step-by-step process, in which:

- multi-focusedness is a market-driven pattern and thus first adopted;
- integration appears to be the organizational answer at a macro level to face the challenge of multi-focusedness;

Table III. The multi-focused manufacturing paradigm around the world

		A1 multi-focusedness			A2 integration					A3 process ownership				
	No.	Business level	Manu-facturing level	*Total A1*	Suppliers	Production/ engineering	Internal production	Manu-facturing strategy	*Total A2*	Delegation	Knowledge of the process	Involvement	*Total A3*	Belonging to the paradigm (final score)
Total	*443*	*0,82*	*0,88*	*0,78*	*0,71*	*0,66*	*0,69*	*0,59*	*0,49*	*0,31*	*0,36*	*0,27*	*0,19*	*0,15*
Japan	16	0,90	0,97	*0,90*	0,77	0,73	0,73	0,81	*0,61*	0,16	0,47	0,49	*0,17*	0,16
Denmark	13	0,79	0,78	*0,69*	0,74	0,79	0,68	0,54	*0,50*	0,57	0,49	0,39	*0,35*	0,25
Sweden	42	0,87	0,89	*0,83*	0,73	0,80	0,80	0,61	*0,57*	0,50	0,40	0,39	*0,30*	0,25
Finland	16	0,82	0,88	*0,79*	0,67	0,75	0,60	0,48	*0,49*	0,44	0,35	0,25	*0,21*	0,20
Norway	11	0,87	0,85	*0,83*	0,87	0,71	0,60	0,50	*0,52*	0,36	0,24	0,40	*0,16*	0,14
Scandinavia	*82*	*0,85*	*0,87*	*0,80*	*0,74*	*0,78*	*0,72*	*0,56*	*0,54*	*0,47*	*0,38*	*0,36*	*0,27*	*0,23*
USA	33	0,89	0,92	*0,85*	0,76	0,86	0,69	0,61	*0,58*	0,30	0,31	0,40	*0,23*	0,19
Canada	14	0,99	1,00	*0,99*	0,64	0,64	0,74	0,46	*0,44*	0,27	0,23	0,18	*0,13*	0,11
North America	*47*	*0,92*	*0,94*	*0,89*	*0,73*	*0,79*	*0,70*	*0,57*	*0,54*	*0,30*	*0,28*	*0,33*	*0,20*	*0,17*
Australia	24	0,83	0,71	*0,67*	0,75	0,87	0,76	0,66	*0,60*	0,36	0,30	0,30	*0,19*	0,15
Brazil	21	1,00	0,98	*0,99*	0,78	0,68	0,72	0,67	*0,55*	0,28	0,43	0,27	*0,23*	0,18
Mexico	51	0,73	0,96	*0,77*	0,72	0,36	0,72	0,67	*0,43*	0,22	0,30	0,09	*0,10*	0,09
Argentina	28	0,28	0,93	*0,80*	0,62	0,55	0,59	0,70	*0,34*	0,21	0,35	0,27	*0,12*	0,09
Chile	4	0,85	0,88	*0,79*	0,84	0,75	0,75	0,88	*0,41*	0,22	0,21	0,26	*0,03*	0,00
South America	*104*	*0,81*	*0,95*	*0,83*	*0,71*	*0,49*	*0,69*	*0,67*	*0,43*	*0,23*	*0,34*	*0,18*	*0,13*	*0,11*
Portugal	24	*0,86*	0,87	*0,83*	0,60	0,58	0,54	0,58	*0,40*	0,36	0,51	0,31	*0,25*	0,20
Spain	24	0,79	0,85	*0,75*	0,70	0,57	0,71	0,57	*0,47*	0,33	0,38	0,25	*0,21*	0,17
Pen. Iberica	*48*	*0,82*	*0,86*	*0,79*	*0,65*	*0,57*	*0,63*	*0,58*	*0,43*	*0,34*	*0,45*	*0,28*	*0,23*	*0,18*
Italy	34	0,82	0,77	*0,69*	0,73	0,67	0,65	0,54	*0,50*	0,27	0,33	0,28	*0,19*	0,14
Great Britain	27	0,82	0,81	*0,74*	0,78	0,69	0,71	0,46	*0,45*	0,25	0,40	0,25	*0,17*	0,11
Austria	21	0,72	0,77	*0,61*	0,53	0,58	0,61	0,45	*0,36*	0,31	0,38	0,22	*0,20*	0,10
Belgium	2	0,90	1,00	*0,92*	0,25	0,50	0,50	0,37	*0,28*	0,19	0,27	0,17	*0,24*	0,12
Germany	18	0,77	0,86	*0,74*	0,54	0,73	0,59	0,50	*0,45*	0,22	0,36	0,05	*0,10*	0,07
The Netherlands	20	0,66	0,88	*0,69*	0,74	0,63	0,78	0,50	*0,51*	0,30	0,43	0,10	*0,16*	0,12
DM Area	*61*	*0,72*	*0,84*	*0,68*	*0,59*	*0,64*	*0,65*	*0,48*	*0,43*	*0,28*	*0,39*	*0,13*	*0,15*	*0,10*

- eventually, process ownership should provide the local mechanism to support the integration at a micro level.

But, on the average, it is supposed not to be fully recognized yet as the key enabling factor, at the moment. In addition, the implementation of this concept is expected to meet more organizational inertia and cultural barriers. Such a phased adoption of the multi-focused manufacturing paradigm might account for the low orientation to the process ownership; yet, it cannot be overlooked. The investigation of the effectiveness of the new paradigm clearly provides an empirical proof, since the core adopters of the paradigm achieve better and quicker performance improvements than adopters not oriented to process ownership. Our findings with respect to the five specific hypotheses are presented in the following sections.

The geo-economic context

The basic hypothesis about the diffusion of the paradigm in the most advanced countries appeared to be confirmed. The orientation to the multi-focused manufacturing paradigm seems to be present in different economic areas, even though not uniformly. The country factor is strongly related to the degree of belonging to the paradigm and also to the three principles and all their subprinciples. In fact the one-way ANOVA tests the probability p that the differences in the mean score of the national samples is random less than one per cent for all the sub-principles scored in Table III. In particular, the Scandinavian area appears to be much oriented to the paradigm, with far higher levels than the mean of the sample for all the three aspects – delegation, knowledge of the process and involvement – of process ownership. Also the average score of integration exceeds the mean of the sample and particularly the integration of production-engineering. Japanese companies confirm to be strongly oriented to the paradigm for most of the subprinciples. Integration is more pursued than elsewhere and, in particular the link between manufacturing and business strategy seems to make the difference. Mainly because of the heaviness of the hierarchies, i.e. many organizational levels, delegation scores are very low, which negatively affects the score of the Japanese firms. In turn the knowledge of the process and the involvement score is very high. Actually they seem to dominate the rest of the sample as to the orientation to the multi-focused manufacturing paradigm except for the delegation. Companies from the Deutschmark area show the lowest degree of belonging to the paradigm, due to the poor orientation to process ownership. In particular, the German companies in the sample score very low as to involvement and delegation. They tend not to use group incentives, suffer higher short-term absenteeism and enjoy less improvement suggestions. Consequently, the average level of involvement is far below the mean of the sample. In addition, those companies maintain a highly centralized control of the production system, which causes the low level of delegation. US companies stand out for their effort to integrate production and engineering,

and they are also markedly oriented to the involvement of the workers. The multi-focused manufacturing paradigm seems to be adopted also in the NICs. For example, Brazilian companies proved to be extremely multi-focused, to pursue different kinds of process integration, and to commit themselves to develop the knowledge of the process in the workers. Indeed, the Brazilian sample is biased towards the best-practice companies, often by foreign corporation, while most of the national samples do not show such a bias.

It is interesting also to note that the philosophy of the multi-focused manufacturing paradigm seems to overcome some unfavourable national conditions, e.g. the shortage of well-educated manpower, the poverty of the infrastructures and the low labour cost that is expected to attract mass productions rather than lean ones, at least when in the track of a global, corporate culture.

The industrial context

The multi-focused manufacturing paradigm is widely adopted within the assembly industry. Widespread orientation to the paradigm has been detected not only in the ISIC 384, which in the database is mainly formed by car assemblers or car component producers. Indeed the electrical and machinery industry show the highest orientation to the paradigm on the whole (degree of adoption 0.17 and 0.19, respectively). Multi-focusedness still remains more pursued within the transport industry (score = 0.82 vs 0.78 in the whole sample), even though no statistical significance of the differences was discovered. On the contrary, the one-way analysis of variance (ANOVA) test revealed that the industry factor significantly affects only the process ownership ($p = 0.008$) and mainly delegation ($p = 0.001$) and in this case the electrical and machinery industry far exceed the other assembly industry (0.38 for both vs 0.27-0.29 for others).

Company-size

Company size is strongly related to the adoption of the paradigm. Small companies show lower scores than large and medium-sized ones (0.13 vs 0.18). The differences are statistically significant for all the three basic principles: as to the multi-focusedness (T-test: $p = 0.015$) the difference mainly depends on the business level ($p = 0.010$); in the case of integration ($p = 0.002$) the dominance of large companies can be traced back to the very differential integration between business and manufacturing strategy ($p = 0.000$); finally the superior orientation to process ownership ($p = 0.003$) within the large companies mainly relies on their capability to develop the knowledge of the process within their workers ($p = 0.050$). Two-way ANOVA allows us to state the independent influence of the size factor. In fact, size and industry can explain separately the adoption of the paradigm

within the sample, while no significant interaction was detected for all the principles and their sub-principles. Quite the same was found for size and country factors, though process integration shows some joint effect of the two factors. In fact, the US and the Japanese units within the sample are also larger than the other, so it is hard to extract size or country as independent factors.

The multi-focused manufacturing paradigm and performance improvements

The effectiveness of the multi-focused manufacturing paradigm is linked to the capability it gives the adopters to improve the performances of the production systems; to improve and speed up performance than the non adopters, thus catalysing the improvements arising from single action programmes. The operationalization of the different degrees of belonging to the paradigm allows us to test the hypotheses about the effects of its adoption on performance improvements, through the framework previously described – the "starmodel"– which allows us to distinguish among different degrees of adoption of the multi-focused manufacturing paradigm.

The 443 processable companies had the following distribution over the "starmodel": 83 companies (19 per cent) of the sample could be classified as core adopters; approximately 36 per cent of the companies resulted in stars – i.e. with a score higher than the mean on two principles out of three, the remaining 45 per cent represented poor scores or non-adoption at all.

It seems that the multi-focused manufacturing paradigm generally provides its adopters with a higher improvement capability compared to non-adopters.

Looking at the global sample in Table IV it appears that:

- The adopters of the paradigm are better capable of improving their performances than non-adopters on almost all performance criteria. There is a general dominance of the adopters over the non-adopters. In fact, when comparing the adopters with the rest of the sample (stars and non adopters) four differences in performance improvements are significantly better, namely: inventory turnover; speed of product development; customer service and delivery lead time (see Table IV).
- Connected with the stars and different innovation tracks we found that partial adoption of the paradigm also resulted in advantages in a subset of performances, i.e. a partial dominance over the non-adopters.
- As full adoption is a general dominance and partial adoption is a partial dominance as to performance improvement, the fuzzy-logic approach is enforced. This implies that the simultaneous presence of the three principles enforces improvement gains (the more you put together the more you gain).

These findings support the idea that the multi-focused manufacturing paradigm requires consistency and leads to effectiveness, since it allows companies to improve more so. The empirical evidence, and in particular the conclusion of "partial adoption is partial dominance and full adoption is general dominance", is also

Table IV. Performance improvements within different classes of adoption of the multi-focused manufacturing paradigm

Performance criteria	Core adopters	Stars non-adopters	Average improvements *t*-test significance (%)	Stars	Non-adopters	*t*-test significance (%)
Conformance to specification	39.87	26.04		32.82	21.10	
Unit manufacturing cost	16.80	12.61		16.14	9.45	
Inventory turnover	40.87	22.38	1.9	28.84	18.01	
Speed of product development	29.49	15.55	0.8	18.11	13.76	
On-time deliveries	46.35	21.60		27.52	16.63	1.9
Equipment changeover	25.82	16.21		20.47	13.32	2.7
Market share	12.56	11.16		18.97	5.66	
Profitability	8.12	10.27		16.16	7.09	
Customer service	26.99	17.83	4.4	22.46	13.99	0.6
Manufacturing lead time	45.95	23.07		31.10	16.35	0.4
Procurement lead time	36.03	15.12		18.37	12.33	
Delivery lead time	36.28	19.75	1.5	22.77	16.53	4.1
Product variety	19.03	13.03		13.06	12.91	

coherent with the idea of cumulative performance improvements[20] associated with the implementation of practices increasingly oriented to the paradigm.

Having said this, some comments must be mentioned as well. Given the data of IMSS, no strict causality can be inferred in an absolute sense between the degree of the adoption of the paradigm and performance improvements. As Hamblin and Lettman[26] have pointed out, the usual statistical tests do not allow us to state a causal link between techniques and performances. In fact one may contend that the performance improvements, for example in inventory turnover and market share, can create additional resources (cash-flows) to be invested in the multi-focused manufacturing, so that the causal link would be the reverse (more improvements: innovation towards the multi-focused manufacturing). To state strict causality we should employ two-way models based on time series on the two classes of variables (as with Granger causality[27]), which we cannot do at the moment, given the non-longitudinal structure of the IMSS survey. So, from a methodological perspective we simply tested the presence of multi-focused manufacturing and performance improvements at the same time. Yet, when considering manufacturing performances (cost, delivery time, etc.) rather than business ones (profitability and market share), the causal link between the degree of adoption of the paradigm and the degree of performance improvements may be reasonably assumed.

Innovation tracks

The last purpose of this contribution is to explore the patterns that companies can follow to reach core adoption of the multi-focused manufacturing paradigm.

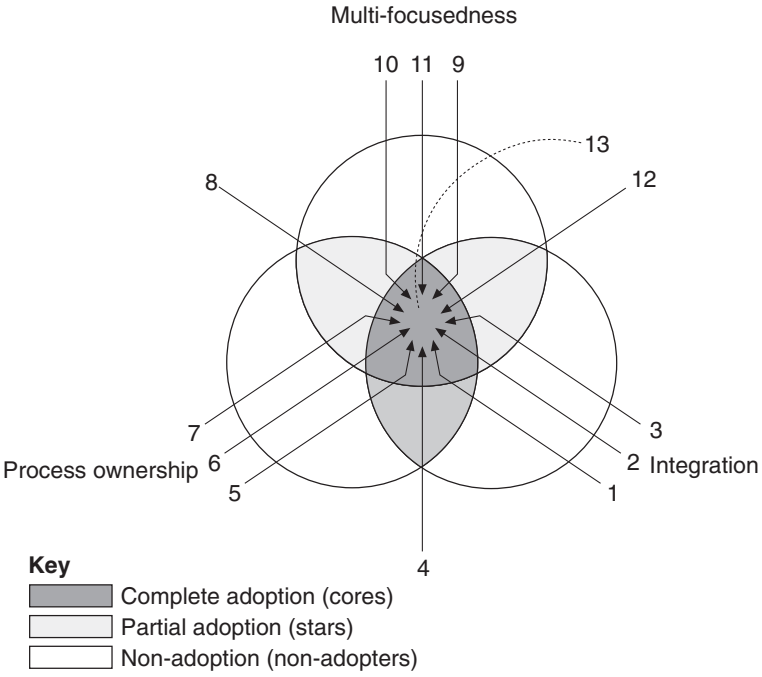

Figure 3. Innovation tracks

In theory, 13 different paths (see Figure 3) can be distinguished. The IMSS data show that some of them are more favoured by companies than are others. In the total sample:

- 16 per cent of the companies are process ownership adopters, i.e. score higher than the mean (0.19) of the sample; in other words, a relatively small number of companies score above a relatively low mean;
- 50 per cent of the companies are process integration adopters, i.e. score higher than the mean (0.49) of the sample: in other words, a relatively average number of companies score above a relatively average mean;
- 59 per cent of the companies are multi-focusedness adopters, i.e. score higher than the mean (0.78) of the sample: in other words, a relatively high number of companies score above a relatively high mean

This seems to imply that the favoured paths are those starting with the implementation of multi-focusedness. These are followed closely by those starting with the implementation of process integration. Finally, these in turn are followed on a considerable distance by those starting with the implementation of process ownership.

The different paths can be explained from a theoretical point of view as follows. An incremental approach towards full adoption starts with the

implementation of process integration, followed by process ownership and, finally, multi-focusedness (path 1). This approach is an example of: "strategy follows process follows organization"; "Jobs must often be specialised vertically because they are specialised horizontally"[28]. This implies that the first logical step has to be job enlargement (process integration), followed by job enrichment (process ownership), rather than the other way around. A more radical approach is path 4, that involves the simultaneous implementation of process integration and process ownership using, for example, semi-autonomous groups or self-managed teams. A well-known example of this approach is the Uddevalla plant[29]. These approaches lay the foundations required for the organization to become really strategically flexible (rather than "just" multifocused).

Two other approaches represent companies that start with the implementation, or are based on the presence, of multi-focusedness. Typically, companies following path 9 (multi-focusedness, then process integration and then process ownership) and 12 (process integration plus multi-focusedness and then process ownership) are multi-purpose, do-all plants and, hence, not optimally efficient. They create the necessary conditions, i.e. process integration and process ownership, not only to increase their efficiency, but also to be able to make the next step to strategic flexibility. The most radical approach provides to implement simultaneously the three principles (path 13); this case mainly occurs in a greenfield situation.

The existence of different paths that non-adopters can follow in order to become core adopters shows that companies face many options when considering the adoption of the multi-focused manufacturing paradigm. This supports the idea of the existence of a considerable design space for a company to choose its own way to the paradigm.

Conclusions

This article set the hypothesis of the emergence of the multi-focused manufacturing paradigm, based on the simultaneous implementation of strategic multi-focusedness, integration of business processes and process ownership. It also proposes a model that allows the evaluation of the orientation of a company to the paradigm and thus makes possible the investigation of its diffusion, the performance improvement capacity it provides, and the innovation paths through which companies can implement it.

The paradigm rises as a coherent set of principles underpinning the wide range of techniques and approaches for the innovation of the manufacturing systems, and provides manufacturers with a higher level of strategic flexibility. The identification of the paradigm has been based on internal and external consistency, as implied by today's business environments. Such a post-Fordist paradigm embodies both established previous experiences and radically new elements. It has been operationalized through a fuzzy-logic and hierarchical methodology. Using data from a sub-sample of 443 companies from the International Manufacturing

Strategy Survey database, the adoption of the paradigm has been detected across a wide range of countries. Also large cross-industrial transferability emerges. Furthermore, large companies appear to be more oriented to the paradigm than small ones. On the whole, process ownership is not very much implemented at the moment. It is expected to be the most difficult part of the paradigm to reach, given that the orientation to the multi-focused manufacturing paradigm is a step-by-step process rather than a radical "turn-key" switch. In addition, big differences across countries have been found about process ownership, which requires more interpretation on the basis of cultural and institutional differences. The empirical evidence also suggest that a higher degree of belonging to the paradigm results in a higher performance improvement. This leads us to conclude that the three principles re-enforce one another. Finally, the existence of different innovation tracks to approach the multi-focused manufacturing paradigm supports the idea that it does not act as a new "one best way" to organize manufacturing activities, but actually provides considerable space for different manufacturing strategies. Further investigation is currently performed on this issue.

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Appendix 1.

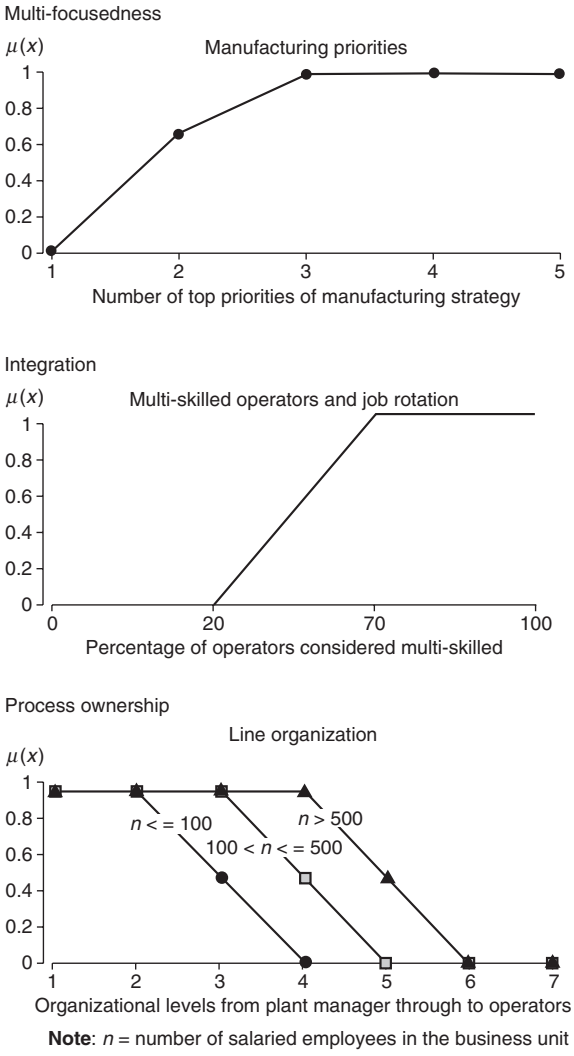

Figure A1. The membership functions (some examples)

Appendix 2. The aggregation operators

AND	min	$\{\mu_a(X), \mu_b(X)\}$
FUZZY AND	α*	min $\{\mu_a(X), \mu_b(X)\}$ + (1 – α) * average $\{\mu_a(X), \mu_b(X)\}$
FUZZY OR	α*	max $\{\mu_a(X), \mu_b(X)\}$ + (1 – α) * average $\{\mu_a(X), \mu_b(X)\}$
OR	max	$\{\mu_a(X), \mu_b(X)\}$
FUZZY AND CONDITIONED	if $m_a(X) = 0$ or $m_b(X)$ / then 0 *else FUZZYAND*	

Appendix 3. The dropping procedure

The standard procedure used to select processable companies is aimed at determining which are the companies that can be assigned a correct score as adopters or non-adopters of the paradigm. The problem concerns missing answers to some of the questions used in the filter. The following rules were used when processing a single company:

- a *missing* value prevails over a *zero* value (non-orientation to the paradigm) if they are combined either through an *OR* or a *FUZZY OR,*
- a *missing* value prevails over a generic *non-zero* value (some orientation to the paradigm) if they are combined either through an *AND* or a *FUZZY AND,*
- in the other cases it is possible to evaluate correctly the fuzzy score of the aggregation of a missing information with whatever data. In fact, *"missing" or "non-zero"* $\Longrightarrow$ *"non-zero"* and *"missing" and "zero"* $\Longrightarrow$ *"zero"*;
- this algorithm is pushed from the leaves of the filter up to the three basic principles of the paradigm;
- a company is discarded if it is impossible to assign a fuzzy score to each of these principles.

3.2 Review and Outlook

3.2.1 Background

It is generally accepted that the foundations of what is now known as manufacturing strategy were developed at Harvard in the 1940s and 1950s. Researchers started looking at industries and began to see that there were many different ways in which companies were choosing to compete within particular industries. These in turn were accompanied by different choices concerning production technology and production management. The development of the field of manufacturing strategy was based on the seminal work of Skinner (1969), and developed further by researchers and teachers such as Hayes et al. (1988). The field of manufacturing strategy was built around a number of important principles. First, that there should be alignment between the market-based priorities (order winners) and the priorities or choices within the manufacturing plant. Second, that the choice of process should be based on the product and product domain characteristics and in particular the product volume and variety. So for example, high volume commodity products where the market competed on costs, needed a production system also aligned to low cost and this in turn would require line-based manufacturing processes. Building on this, Skinner (1974) proposed the concept of the focused factory. This argued that a plant should be focused on a limited set of competitive priorities and that there should be internal as well as external consistency. Skinner recognised that organisations may have to deal with different markets and proposed the concept of a plant within a plant have different focus.

There was further refinement by Hayes et al. (1988) in their product process matrix. They viewed process both in a static and in a dynamic mode. In a static mode they argued that the choice of process was contingent on the context of manufacture, in particular the volume and variety of the production task. They showed how misalignment could lead to poor manufacturing and business performance. They also argued that as markets evolved and changed, so did the required process and hence focus. Finally, they also related this to more complex environments such as multi-process, multi-product environments where there was a need for focused plants.

Around this time, a step change was beginning to take place in manufacturing technology, with the development of more agile and flexible manufacturing. Initially the attention was around flexible manufacturing systems (FMS). Concurrent with this, scholars began to consider the phenomenon of Mass Customisation, where manufacturing technology would allow products to be tailored to individual needs. Over his period, the potential of just-in-time production (now called lean) was beginning to be realised as companies slowly explored the nature and the implementation of the Toyota Productions System.

3.2.2 The Paper

However, even though technologies and manufacturing practices such as lean production were rapidly evolving, and markets were changing, the core principles of Manufacturing Strategy had not been challenged as to how they might reflect this rapidly changing environment. Spina and his co-authors were among the first to recognise that *"As a result, both the internal organization of the factories and the external environment—including market demand, technology development, workforce education and expectations, labour and capital market—appear very different today from the general features that dominated the industrial development in the past."* (p20). They argued that this was a paradigm shift. He and his colleagues then set out to explore whether a new paradigm was emerging and for example:

- Can a new manufacturing paradigm be identified, despite the different strategic choices that industrial companies make and the different internal and external conditions they have to meet?
- Is this paradigm a definite breakthrough with Fordism? Is it possible to find out a limited set of shared principles to design and manage the production systems, that pools different models and paths of innovations?
- If the paradigm exists, how can it be defined and operationalised to support empirical investigation?
- How is the emerging paradigm adopted across countries and industries?
- What is the performance improvement along specific measures that comes from the orientation to the paradigm?
- Are there different paths to achieve the full orientation to the paradigm?

Based on this a "multi-focused paradigm" was proposed. This paradigm is based on three elements:

1. *Multi-focusedness and strategic flexibility*. This relates to the manufacturing strategy. The multi-focused manufacturing paradigm drives companies to pursue a number of different objectives, traditionally regarded as antithetical, simultaneously, rather than focusing on specific objectives considered mutually exclusive. In addition, the paradigm implies a strategic flexibility, that is the ability to rapidly shift competitive and manufacturing priorities from one set of goals to another, within the same manufacturing system. This principle challenges the traditional assumption about rigid trade-offs involving manufacturing performances.
2. *Integration*. This relates to production organisation from a macro-structural perspective. It entails a resolute process focus, and process integration pursued across the internal functions and with both customers and suppliers. The historical emphasis on functional optimisation should be abandoned in favour of a redesign of the company pivoted by the concepts of operating continuity, and process integrity, across the functional barriers.
3. *Process ownership*. This relates to production organisation, from a micro-structural perspective. It aims at involving all employees at any hierarchical level, in decision making and problem solving. Delegation, involvement and knowledge

of the process are embodied in this principle. The ultimate purpose is to develop at least some degree of local problem-solving capabilities, in order to detect and resolve process anomalies as soon as possible, and to avoid time consuming hierarchical referrals.

The implementation of these three principles should be approached as an integrated problem, in order to achieve the required external and internal consistency.

Having proposed a new paradigm, the research set out first to operationalise it and then to test it. A series of hypotheses were developed about its acceptance and use and its effectiveness. To do this data was analysed from the International Manufacturing Strategy Survey. This survey has proved to be a valuable resource for research into manufacturing strategy and policies and is still being run today.

The results of the empirical study were very interesting. First there were strong contrasts between the levels of adoption of the three elements of the new paradigm. Strategic multi-focusedness was widely adopted across the sample and across all regions. However, there were mixed results for integration and generally low levels of adoption of process ownership. In the latter two, a number of country differences stood out. First, Scandinavian countries had higher scores for all three elements. Cultural differences were evident, Japan scored highly on all except delegation, and companies from the Deutschmark (pre-Euro) area showed poor process ownership in particular. In addition, as might be expected, adoption was higher in larger companies and more developed countries. The data also indicated that those who adopt all three elements achieve superior performance to those with partial adoption who in turn achieve higher performance than non or low adopters.

The paper is partly framed in terms of going beyond Fordism. I feel that, although the concept of Fordism was widely used in behavioural management and economics, by the time the research was done the extant developments in manufacturing strategy were already moving "beyond Fordism", though process ownership can be seen as a further move away from Fordism.

This pattern of high and low adoption of the three elements of the paradigm raises interesting questions. It is argued that adoption of the paradigm may be a step-by-step process and that at the time of the research companies were in the early stages of adoption. A second possibility is that cultural barriers hold back process ownership. However, unfortunately the first of these cannot be easily tested in a cross-sectional study. Another possibility not discussed is that the multi-focused paradigm may not actually consist of these three elements and that although process ownership can be desirable, it is not a necessary component of strategically flexible production. The reference to the Udevalla plant as an example of simultaneous implementation of process integration and process ownership using, for example, semi-autonomous groups or self-managed team is interesting, but raises questions due to the subsequent failure and closure of the plant.

3.3 The Significance of the Paper

As discussed above, this paper is an important milestone in the development of the field of manufacturing strategy. At the time of its publication, the field of manufacturing strategy had begun to realise the importance of the dynamic nature of markets, but had taken a rather conservative approach to developing strategies to dealing with this. Flexibility was still seen as the opposite of focus and thus something that in the short term was a trade-off. This paper was the first to properly address this and to question the traditional trade-offs. The proposal that a manufacturing strategy for the emerging market and process context needed to be strategically flexible and that this in turn required multi-focusedness was a major step change for the area. That it had been empirically tested and found to impact performance gave it greater validity.

It has long been argued that flexibility is an important dimension in manufacturing. Slack (1983) both signalled this and provided a set of dimensions for flexibility in manufacturing. This in turn led to the increasing focus on flexibility as a manufacturing capability. The work of Spina et al. (1996) was a major step forward from this as it saw flexibility not just as a capability but as a key strategic element for manufacturing. As a result of this the focus of researchers on flexibility evolved. For example, building on Spina's work Oke (2005, p. 973) argued that "manufacturing flexibility had been heralded as a major competitive weapon for manufacturing organisations operating in increasingly uncertain environments and turbulent markets. It has been argued that manufacturing flexibility has the capability to change levels of production rapidly, to develop new products more quickly and respond more rapidly to competitive threats."

It is interesting to observe the continuing debates on flexibility, particularly when associated with technology. Initially these led to much consideration of "the factory of the future" (Jelinek and Goldhar 1984). The earlier development of flexible manufacturing systems had been hailed as a breakthrough, but subsequent research found that they actually did not greatly influence the overall flexibility of a manufacturing plant. A technology in isolation without the clear strategic flexibility view and elements proposed by Spina et al. (1996) may not fulfil its potential. Cagliano and Spina (2000) examined whether advanced manufacturing technologies were important for strategic flexible production. Data showed that while core adopters do not use stand-alone AMT more than the other groups, they have a higher level of computer integration, in particular in their forefront departments. However, the use of integrating technologies varies much within the core adopters, suggesting that Strategically Flexible Production does not necessarily require massive information technology support. This was further confirmed by the analysis of performance improvements. The mere adoption of stand-alone AMT per se did not provide companies with superior improvements in performance. Whereas, Strategically Flexible Production alone or combined with a higher level of integration of stand-alone AMT fostered increased time responsiveness.

Today we are seeing a repeat of these debates, but instead of flexible manufacturing systems or the factory of the future, the focus is on 3D printing. To the casual observer, much of the discussion of 3D printing seems over-hyped with claims similar to those put forward, decades before, for FMS and the factory of the future, without reference to markets or manufacturing strategy. Today's scholars should heed Spina et al.'s (1996) work before making all the claims that they are making about the latest technology.

The issue of trade-offs in manufacturing has been a long-running debate. There has been a natural feed-in from Spina et al.'s (1996) work to the debates around both lean production and trade-offs. An important element of the proposed paradigm was to challenge the traditional assumption about rigid trade-offs involving manufacturing performances. The notion of trade-offs in manufacturing go back to Skinner's (1969, p. 138) seminal article where he states: "a production system invariably involves trade-offs and compromises and so must be designed to perform a limited task well, with that task defined by strategic objectives." Rosenzweig and Easton (2010) point out that "a considerable debate exists in the operations strategy literature regarding whether manufacturing can focus on multiple competitive capabilities with sacrificing performance of another". Spina's work was one of the important precursor to this debate and was an input in the meta-analysis by Rosenzweig and Easton. The findings of this study were consistent with those put forward by Spina et al. (1996).

Lean production should be a contributor to flexibility and multi-focus. But as Lewis (2000) points out, there should be trade-offs involved in the use of lean production. However, his empirical work found that the expected trade-off between lean methods and innovation was not present. He argues that "A number of operations authors have suggested that it is possible to create a strategically flexible production model that accommodates this apparent contradiction (Spina et al. 1996). This requires substantial further investigation."

A number of subsequent research studies have focused on using or exploring some of the specific ideas from Spina et al. (1996). Beach et al. (2000) examine strategic flexibility. Takala et al. (2006) specifically examined multi-focused strategies. They state that competitive strategies—especially in manufacturing industry—changed dramatically from focused to multi-focused priorities. However, this change brings about a great challenge for the successful implementation of these strategies. They use the sand cone model to explore this.

3.3.1 Summary

The paper "Strategically flexible production: the multi-focused manufacturing paradigm", was an important milestone in the development of the field of manufacturing strategy. First, it was both timely and was the first to challenge the established paradigms of manufacturing strategy. Voss (1995) set out the paradigms of manufacturing strategy, but did not challenge them. In doings so Spina et al. (1996) put

forward a new paradigm that both reflected the evolution of manufacturing and challenged our view of trade-offs and the assumptions behind some of the core concepts such as the focused factory. Importantly, it was not just conceptual, but the paradigm was operationalised and empirically tested both for adoption and impact. It would be good if many of the conceptual papers that we read today would do the same. It was the first research to fully recognise the major changes in technology, markets, the organisation and management of manufacturing. Subsequent empirical research has proved to be supportive of the new paradigm. As such it has been a platform for future work in and the evolution of the field. There is a need today to remember the themes from this research in areas such as 3D printing.

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